MAGIC

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The Middle Ages took magic seriously, though it was not a key issue for that period of European history, as it had been in late antiquity. Many medieval theologians treated magic with fear or loathing, in fact, and philosophers were often indifferent. But in the late fifteenth century, magic enjoyed a remarkable rebirth, acquiring the energy that kept it at the center of cultural attention for nearly two hundred years, as great philosophers and prominent naturalists tried to understand or confirm or reject it. After Marsilio Ficino (1433-99) took the first steps in the renaissance of magic, prominent figures from all over Europe followed his lead: Giovanni Pico della Mirandola (1463-94), Johann Reuchlin (1455-1522), Pietro Pomponazzi (1462-1525), Paracelsus (Theophrastus Bombastus von Hohenheim, c. 1493-1541), Girolamo Cardano (1501-76), John Dee (1527-1608), Giordano Bruno (1548-1600), Giambattista Della Porta (c. 1535-1615), Tomasso Campanella (1568-1639), Johann Baptista van Helmont (c. 1580-1648), Henry More (1614-1687) and others of equal stature. Eventually, however, as Europe's most creative thinkers lost confidence in it, magic became even more disreputable than it had been before Ficino revived it. Around 1600, some reformers of natural knowledge had hoped that magic might yield a grand new system of learning, but within a century it became a synonym for the outdated remains of an obsolete world-view.[1] Before examining its extraordinary rise and fall in post-medieval Europe, we can begin with magic as described by one of its most voluble advocates, Heinrich Cornelius Agrippa von Nettesheim (1486-1535), a German physician and philosopher.

AGRIPPA'S MAGIC MANUAL

No one knew the risks and rewards of magic better than Agrippa. His notorious handbook, *De occulta philosophia*, circulated in manuscript by 1510, though it was printed only in 1533, over the complaints of Dominican inquisitors. Meanwhile, he had written another famous book, *De incertitudine et vanitate scientiarum* (*On the Uncertainty and Vanity of the Sciences,* 1526), where he recanted magic for religious reasons that had become urgent in the early years of the Reformation. Agrippa's change of heart – not really a change of mind – did nothing to diminish the influence of the

[1]D.P. Walker, *Spiritual and Demonic Magic from Ficino to Campanella* (University Park: Pennsylvania State University Press, 2000); Frances Yates, *Giordano Bruno and the Hermetic Tradition* (London: Routledge and Kegan Paul, 1964); Brian P. Copenhaver, "Astrology and Magic," in *The Cambridge History of Renaissance Philosophy*, ed. Charles Schmitt et al. (Cambridge: Cambridge University Press, 1987), pp. 264-300; "Natural Magic, Hermetism and Occultism in Early Modern Science," in *Reappraisals of the Scientific Revolution*, ed. D. Lindberg and R. Westman (Cambridge: Cambridge University Press, 1990), pp. 261-301; "Did Science Have a Renaissance?" *Isis*, 83 (1992), 387-407; "The Occultist Tradition and its Critics in Seventeenth Century Philosophy," in *The Cambridge History of Seventeenth Century Philosophy*, ed. Michael Ayers and Daniel Garber (Cambridge: Cambridge University Press, 1998), I, 454-512.

Occult Philosophy, which was enormous.[2]

Agrippa's occult philosophy was of great importance for natural philosophy because of its account of natural magic, which he described as

> the pinnacle of natural philosophy and its most complete achievement…. With the help of natural virtues, from their mutual and timely application, it produces works of incomprehensible wonder…. Observing the powers of all things natural and celestial, probing the sympathy of these same powers in painstaking inquiry, it brings powers stored away and lying hidden in nature into the open. Using lower things as a kind of bait, it links the resources of higher things to them … so that astonishing wonders often occur, not so much by art as by nature.

The plan of Agrippa's book reflects the triple hierarchy of his cosmos, where causality runs from above to below, from Ideas in God's mind down through spiritual intelligences and heavenly bodies to animals, plants and stones beneath the moon. Humans can ascend the magical channels that carry divine energies down to earth. Magicians can attract powers from on high by manipulating qualities, quantities and minds: qualities of objects made of earthly matter in the lowest elementary world; quantities (figures and shapes as well as numbers) in these same lowly things and in the more sublime objects made of celestial matter in the middle world of heavenly spheres; and immaterial angelic minds, stationed in the highest intellectual world and free of bodily quality or quantity. These three realms correspond to the three parts of Agrippa's occult philosophy: natural, mathematical and ritual.[3]

Currents of power fuse the three realms in Agrippa's ambitious theory of magic. Just as forms flowing from God's mind reach down to the lowest material objects, so elements and qualities of matter extend upward, ever more refined, suffusing the whole hierarchy. Binding the whole together is the tenuous substance called spirit (*spiritus*, *pneuma*), not quite matter and not quite mind, the vehicle for exchanges of power between bodiless and embodied things. While in one sense the whole is embodied, through sympathies and similitudes, in another sense and through the same forces it is ensouled. A world-soul mirrors not only human souls but also those of angels and demons, unencumbered by bodies and therefore very powerful. To energize links among minds, souls, spirits and bodies, the magus starts with the natural magic of objects here on earth and moves up through mathematical, spiritual and psychological magic, working on the self and on others and entering the middle world of figures and celestial influences, where the power of human imagination resonates with great effect.[4]

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[2]*Henrici Cornelii Agrippae ab Nettesheym ... opera quaecumque hactenus vel in lucem prodierunt vel inveniri potuerunt omnia...* (Lyon: Beringi fratres, c. 1600), I, a-526; Charles G. Nauert, *Agrippa and the Crisis of Renaissance Thought* (Urbana: University of Illinois Press, 1965), pp. 30-3, 59-60, 98-9, 106-15, 194-214, 335-8; Walker, *Magic*, pp. 90-6.

[3]Agrippa, *Opera*, I, 1-4, 153-6, 310-11; II, 90-1.

[4]Agrippa, *Opera*, I, 5-6, 18-19, 25-36, 40, 43-5, 68-70, 90-2, 128-38.

Up to this point, the occult philosophy might be acceptable for a pious Christian; it does not yet involve the spiritual persons – angels and demons – with whom the Church forbade dealings outside her own institutions. But Satan and his minions are cunning: with all the best intentions, a magus who starts with natural objects may end with illicit rites and evil spirits, inviting condemnation by the Church. Witches use both types of magic, natural and demonic, for their harmful spells (*maleficia*), which is where popular and learned magic merge most destructively in Agrippa's system.[5]

By the time Agrippa wrote, pagans and Christians had been testing the boundary between natural and demonic magic for two millennia. He knew the dangers, which explains why he came to disavow magic so passionately. Nonetheless, his arguments on behalf of a learned, philosophical magic are more compelling than his declamations against it. His occult philosophy is systematic, comprehensive, and grounded in authority and evidence, but it is not original. It is a vulgarization of the ancient magic revived in the fifteenth century by Ficino, summarized in his *De vita libri tres* (*Three Books on Life*, 1489) and then developed by Pico, Reuchlin and others – including Pietro Pomponazzi, an Aristotelian natural philosopher whose work on the causes of magical effects was written (but not printed) before Agrippa's book was published in 1533.[6]

Ficino's sources included Greek manuscripts brought to Italy by Byzantine scholars, some arriving even before 1400, others driven west after Constantinople fell to the Turks in 1453. Texts of this provenance, assembled during the Middle Ages and now called the *Corpus Hermeticum*, had long been attributed to the Egyptian god Thoth, whom the Greeks named Hermes Trismegistus. This is the ancestry of the Hermetic writings and of the "Hermeticism" which has been contentious among historians of science ever since Frances Yates claimed that Renaissance magic was Hermetic and that the origins of modern science were to be found in that arcane wisdom.[7]

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[5]Agrippa, *Opera*, I, 18-19, 40, 69-70, 90-2, 137-8, 268, 276, 361, 436-9.

[6]Ficino, *Three Books on Life: A Critical Edition and Translation with Introduction and Notes*, ed. and trans. Carol Kaske and John Clarke (Binghamton: MRTS, 1989); Copenhaver, "Number, Shape and Meaning in Pico's Christian Cabala: The Upright *Tsade*, the Closed *Mem* and the Gaping Jaws of Azazel,' in *Renaissance Natural Philosophy and the Disciplines*, ed. A. Grafton and N. Siraisi (MIT Press, 2000), pp. 25-76; "The Secret of Pico's *Oration*: Cabala and Renaissance Philosophy," *Midwest Studies in Philosophy*, 26 (2002): 56-81; "Astrology and Magic," pp. 267-85; "Did Science Have a Renaissance?" pp. 387-402.

[7]A.D. Nock and A.J. Festugière, *Corpus Hermeticum* (3rd. ed.; Paris: Les Belles Lettres, 1972), I, xi-xii; Robert S. Westman, "Magical Reform and Astronomical Reform: The Yates Thesis Reconsidered,' in *Hermeticism and the Scientific Revolution: Papers Read at a Clark Library Seminar, March 9, 1974* (Los Angeles: Clark Memorial Library, 1977), pp. 5-91; Ingrid Merkel and Allen G. Debus, ed., *Hermeticism and the Renaissance: Intellectual History and the Occult in Early Modern Europe*, (Washington: The Folger Shakespeare Library, 1988); Brian Vickers, ed., *Occult and Scientific Mentalities in the Renaissance* (Cambridge: Cambridge University Press, 1984); Copenhaver, *Hermetica: The Greek Corpus Hermeticum and the Latin Asclepius in English Translation, with Notes and Introduction* (Cambridge: Cambridge University Press, 1991), pp. xl-xli; "Magic and the Dignity of Man: De-Kanting Pico's *Oration*," in *The Italian*

Scholars have challenged the Yates thesis since it was first proposed. One of their points, recognized long before by Byzantine scribes, is that the Hermetic writings are of two types, now called technical and theoretical. The major theoretical works are the Latin *Asclepius* and the Greek treatises that Ficino put into Latin as the *Pimander*. Their content is spirituality – pious speculation and exhortation about God, the cosmos and the human condition. But these theoretical *Hermetica*, made famous in the Anglophone world by Yates, are not about *magical* theory or practice, which falsifies a large part of her claim that modern science grew out of Hermetic magic.[8]

Other texts attributed to Hermes have been called technical: dozens of works on alchemy, astrology, astronomy, botany, magic, medicine, pharmacy and other practical topics that circulated in the Mediterranean region since antiquity in various languages, including Latin and Arabic. Unlike the theoretical treatises, some were known in the medieval West, disseminating technical information about magic and authenticating it with the name of Hermes. This Hermes, who presided over medieval guides to practical magic, was not Ficino's Hermes, a divine theologian and spiritual adviser.[9] But once Ficino discovered the *Pimander*, making Hermes as canonical as Plato or Plotinus, the old god was there to be exploited by new magicians, who read Agrippa and applied the Hermetic pedigrees less scrupulously than Ficino. When Agrippa listed the first authors of magic, he put Hermes among "the more distinguished masters," setting him alongside the Neoplatonic philosophers whom Ficino rediscovered – Plotinus, Porphyry, Iamblichus and Proclus. But Damigeron, Gog Graecus and Germa Babylonicus turn up on the same page – barbaric names that Agrippa thought to be fit company for Hermes.[10]

Unlike Agrippa, Ficino was a careful explorer of the borderland between myth and history. From deep reading in ancient sources, especially the Church Fathers, he derived a scheme of religious and intellectual history, the ancient theology (*prisca theologia*).

Renaissance in the Twentieth Century: Acts of an International Conference, Florence, Villa I Tatti, June 9-11, 1999, ed. A.J. Grieco et al. (Florence: Olschki, 2002), pp. 311-20; "Natural Magic," pp. 261-6, 289-90.

[8]*Mercurii Trismegisti liber de potestate et sapientia dei: Corpus Hermeticum I-XIV, versione latina di Marsilio Ficino, Pimander*, ed. Sebastiano Gentile (Treviso, 1471; rpt. Florence: Studio per edizioni scelte, 1989); A.-J. Festugière, *La Révélation d'Hermès Trismégiste*, Vol. I: *L'Astrologie et les sciences occultes* (Paris: Belles Lettres, 1981), pp. 67-88; Garth Fowden, *The Egyptian Hermes: A Historical Approach to the Late Pagan Mind* (Cambridge: Cambridge University Press, 1986), pp. 1-11; Copenhaver, *Hermetica*, pp.xxxii-xl.

[9]Festugière, *Révélation*, I, 89-308; Fowden, *Hermes*, pp. 1-4; Copenhaver, *Hermetica*, pp. xxxii-vii, xlv-vii; "Lorenzo de' Medici, Marsilio Ficino and the Domesticated Hermes," in *Lorenzo il Magnifico e il suo mondo: Atti di Covegni*, ed. G.C. Garfagnini (Florence: Istituto Nazionale di Studi sul Rinascimento, 1994), pp. 225-57; "Hermes Theologus: The Sienese Mercury and Ficino's Hermetic Demons," in *Humanity and Divinity in Renaissance and Reformation: Essays in Honor of Charles Trinkaus*, ed. John O'Malley et al. (Leiden: E.J. Brill, 1993), pp. 149-82.

[10]Agrippa, *Opera*, I, 4.

Prominent in this story was the Hermes of Ficino's *Pimander*; unlike the obscure Gog and Germa, he was the reputable author of a pious spirituality, as any reader of Ficino's translation could see. But Hermetic genealogies were deceptive; Cicero had counted four distinct deities called Hermes (Mercurius in Latin) in addition to the Egyptian Trismegistus. The god's multiple personalities, some attached to magical texts, some not, easily fused into a single Hermetic persona during the sixteenth century, until Isaac Casaubon (1559-1614) proved that the *Hermetica* were not nearly as old as Ficino had thought.[11]

Ficino believed that Hermes was a contemporary of Moses and that he had founded a tradition of human wisdom running parallel to the divine revelation of scripture and leading to the teachings of Plato and his successors. After Casaubon devalued the Hermetic works in 1614 by redating them to the early Christian era, Ficino's ancient theology lost its reputation, but lost it slowly. In the 1690s, Isaac Newton (1642-1727) still found it useful for grounding his views about God and space in mythic tradition, though Newton's published works reveal this interest only in faint allusions. Meanwhile, once Ficino had resurrected it, the ancient theology reinforced one of the three main motives for belief in magic by educated Europeans: the *historical* authority of a venerated past. Some of the ancient wisdom that Ficino revived, especially its Neoplatonized Aristotelianism, provided authority and content for another basis of occultist belief, which was *theoretical*. Not only the Neoplatonists but also Galen, Avicenna, Thomas Aquinas and other thinkers of the first rank – pagan and Christian, ancient and medieval – contributed to the philosophical theory of magic published by Ficino in 1489 and then popularized by Agrippa. Finally, many readers who found this theory philosophically convincing also took it to be confirmed by experience. *Empirical* information supplied a third basis for belief in occultism.[12]

Indeed, empirical details formed the bulk of Agrippa's compendium, illustrating its theory and making it concrete. Agrippa turned again and again to lists of natural objects long regarded as mysterious because their appearances were strange, their mechanisms unknown or their effects rapid and unusually strong: the magnet, carbuncle, heliotrope, peony, tarantula, basilisk, dragon, electric ray, ship-stopper and hundreds of others. Without a theory to explain them, however, Agrippa's long lists of magical objects would

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[11]Cicero, *De natura deorum*, 3.22.56; Yates, *Bruno*, pp. 398-440; Walker, *The Ancient Theology: Studies in Christian Platonism from the Fifteenth to the Eighteenth Century* (London: Duckworth, 1972); Frederick Purnell, "Francesco Patrizi and the Critics of Hermes Trismegistus," *Journal of Medieval and Renaissance Studies*, 6 (1976), 155-78; Anthony Grafton, *Defenders of the Text: The Traditions of Scholarship in an Age of Science, 1450-1800* (Cambridge: Harvard University Press, 1991), pp. 145-77.

[12]J.E. McGuire and P.M. Rattansi, "Newton and the 'Pipes of Pan,'" *Notes and Records of the Royal Society*, 21 (1966), 108-43; Copenhaver, "Astrology and Magic"; "Natural Magic"; "Did Science Have a Renaissance?"; *Hermetica*, pp. xlvii-viii; "A Tale of Two Fishes: Magical Objects in Natural History from Antiquity through the Scientific Revolution," *Journal of the History of Ideas*, 52 (1991), 373-98.

have been meaningless. Encyclopedias, lapidaries, herbals and bestiaries as well as works on alchemy, astrology and medicine had supplied such lists for centuries, but the theory behind them was weak, because its strongest voices, the ancient Neoplatonists, remained faint until the generation before Agrippa, when Ficino, Pico, and other prominent thinkers developed philosophical conceptions of magic using the most authoritative metaphysical, physical and cosmological ideas of the day. Agrippa was the beneficiary of this theorizing. Personal experience and popular culture also confirmed his beliefs about magic, which nonetheless remained a learned and philosophical project – an occult *philosophy*.[13]

Claiming to derive natural magic from natural philosophy, Agrippa started with an exposition of physics and matter-theory – Aristotelian in its terminology and framework but with Neoplatonic elements as well. His physical primitives are the four elements (fire, air, water and earth) and their haptic qualities (hot, cold, wet and dry). These primary qualities of the elements give rise to secondary qualities that account for physical processes important to physicians and natural philosophers: softening and hardening, retaining and expelling, attracting and repelling and so on. Secondary qualities act on parts of bodies to produce tertiary qualities and a myriad of wonders, natural and artificial, from unquenchable fires to perpetual lamps. Emerging from matter and accessible to the senses, all these qualities are called manifest. Other qualities, called occult, arise not from matter but from specific or substantial form – the immaterial form that accounts for a thing's belonging to its species or kind. Except that they derive from form, the causes of occult qualities are unknown; only the magical phenomena caused by them are perceptible, not the occult qualities themselves. These sources of magical power are hidden both to reason and to sense, which is why they are called occult.[14]

Because they do not depend on matter, occult qualities produce strange effects which are out of place or out of proportion to the size of the objects containing them: stones sing in the earth, tiny fish stop great ships in the water, birds of the air eat iron, lizards live in fire. But even the elements themselves are magical. Fire is helpful for ritual magic because it attracts good spirits of light. Earth, implanted celestially with seminal forms,

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[13]Agrippa, *Opera*, I, 21-2, 25-6, 35-6, 39, 45, 47, 51, 57-8, 74, 77, 83, 334; Copenhaver, "Astrology and Magic"; "Two Fishes;" "Occultist Tradition," pp. 454-65; "Natural Magic," pp. 275-80; "Did Science Have a Renaissance?" pp. 396-8; "Scholastic Philosophy and Renaissance Magic in the *De vita* of Marsilio Ficino," *Renaissance* Quarterly, 37 (1984), 523-54; "Renaissance Magic and Neoplatonic Philosophy: *Ennead* 4.3-5 in *Ficino's De vita coelitus comparanda*," in *Marsilio Ficino e il ritorno di Platone: Studi e documenti*, ed. G. Garfagnini (Florence: Olschki, 1986), pp. 351-69; "Iamblichus, Synesius and the *Chaldaean Oracles* in Marsilio Ficino's *De vita libri tres*: Hermetic Magic or Neoplatonic Magic?" in *Supplementum Festivum: Studies in Honor of Paul* Oskar *Kristeller*, ed. James Hankins, et al. (Binghamton, N.Y: MRTS, 1987), pp. 441-55; "Hermes Trismegistus, Proclus and the Question of a Philosophy of Magic in the Renaissance," in Merkel and Debus, *Hermeticism and the Renaissance*, pp. 79-110.

[14]Agrippa, *Opera*, I, 5-22; for more on occult qualities, see below, "Virtues Dormitive and Visual."

spontaneously generates worms and plants. Air transmits celestial influence and reflects virtual images (*species*) of natural objects, conveying telepathic powers that Agrippa himself claimed to have mastered. And "the wonders of water are countless," as Agrippa noted, even in the Gospel, where an angel stirs a pool of water to cure the incurable.[15]

The forms that give rise to occult qualities are celestial, descended from God's Ideas and seeded in lower nature. They reflect the figures of the stars and imprint them as characters, seals or signatures on natural objects: "every species has a heavenly figure that matches it," says Agrippa, "from which a wondrous power of action also comes into it." Magical objects are thus marked by signs of their celestial origins that the magus can detect, just as the astronomer can read the stars and planets. In Agrippa's catalog of planetary signatures, for example, one category of objects descends from Saturn – earthy and watery in its elements, melancholic in humor, sympathetic with lead and gold, with sapphire and the magnet, with mandrake, opium, hellebore and dragon's wort, with "crawling animals that keep to themselves, solitary, nocturnal, gloomy, … slow-moving, eating filth, consuming their young, … the mole, ass, wolf, hare, mule, cat, camel, bear, pig, monkey, dragon, basilisk and toad."[16]

The scores of such lists in Agrippa's book have a practical point. The magician who knows that the constellation Draco and the planet Saturn rule the dragon-plant, for example, can use this information to attract or repel saturnine influence. Natural objects imprinted with forms by the heavens, signed with celestial seals and charged with occult power thus become magical objects when the magus discovers and uses them, concentrating them to attract one influence, separating them to avoid another, creating congruities or incongruities to induce the desired form and make matter fit to receive it. Up to a point, the magic works within nature's domain, which extends through the elementary and celestial levels of Agrippa's world. His various devices to produce magical effects – amulets, rings, charms, drugs, unctions, potions, lamps, lights, fumigations – could, in theory, be wiser, deeper, secret ways to use *natural* objects, avoiding the theologically and morally risky world of demonic minds.[17]

But Agrippa's cosmos is a continuum, where bodies link sympathetically with minds and nature merges into supernature through the medium of spirit, the power of imagination and the transmission of forms. One of the many pictures in Agrippa's book, showing a dragon (fig. 1), illustrates the perils of magical continuity, which lets demons slip into the magician's practice. Summarizing earlier literature on astrological images, Agrippa notes that its authors

> made an image of the Moon's Dragon with Head and Tail, a depiction of that serpent between circles of fire and air.... They made it when Jupiter and the Head ruled the

[15]Agrippa, *Opera*, I, 5-17; John 5:2-9.

[16]Agrippa, *Opera*, I, 23-4, 50-1, 56-62.

[17]Agrippa, *Opera*, I, 57-67, 70-85.

> middle of the sky, … and through this image they wanted to signify a good, lucky demon, depicting its image with serpents. The Egyptians and Phoenicians thought this animal divine above all others … [because] its spirit was sharper and its fire fuller…. But when the Moon was eclipsed in the Tail or badly situated with Saturn or Mars, they made a similar image of the Tail to cause anxiety and weakness and bring on bad luck, and they called it an evil spirit. A Jew put an image like this on a belt of gold and jewels, which Blanche, daughter of the Duke of Bourbon, gave to her husband Peter, King of Spain, ... and when he put the belt on, he seemed to have a snake around him. When the magic power implanted in the belt was discovered, he rejected his wife because of it.[18]

Since angels and demons ruled the upper stories of Agrippa's sympathetic cosmos, while stones, plants and animals lay in the basement but still within reach, the magus who tapped the hidden powers of natural objects ran the risk of attracting angelic or demonic attention, benevolent or malevolent.

THE CREDIBILITY OF MAGIC: TEXT, IMAGE, EXPERIENCE

Words, images and experience, especially vicarious experience stored in books, confirmed the magical powers of physical objects – natural objects like magnets, peonies and dragons, and artificial objects like rings, amulets and automata. The credibility of such objects was rooted in ancient texts, and humanists who recovered and preserved those texts left their magic intact. Faced with Pliny's ancient encyclopedia, for example, with its mass of evidence for magic, most Renaissance editors wanted to strengthen Pliny's authority, not weaken it. Taking up where philology left off, sixteenth-century natural historians from Pierre Belon and Hans Weiditz to Charles de l'Écluse and Ulisse Aldrovandi cited the texts improved by humanist scholarship, thus authenticating the ancient wisdom that legitimized belief in magic. Relying more on old books than new observations, the best that erudition could do was to expose contradictions in the classics, a sure solvent of belief but a slow one. Moreover, some appeals to personal experience actually reinforced the old tales with current examples. Few followed the advice offered by the French essayist Michel de Montaigne (1533-1592): to verify the facts about marvels before trying to explain them.[19]

With no strict regime of correspondence between objects described in books and objects

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[18]Agrippa, *Opera*, I, 68-70, 272-3.

[19]Montaigne, *Essais*, 3.11; Charles G. Nauert, "Humanists, Scientists and Pliny: Changing Approaches to a Classical Author," *American Historical Review*, 84 (1979), 72-85; G.E.R. Lloyd, *Science, Folklore and Ideology: Studies in the Life Sciences in Ancient Greece* (Cambridge: Cambridge University Press, 1983), pp. 135-49; Lorraine Daston and Katharine Park, *Wonders and the Order of Nature* (New York: Zone Books, 1998), pp. 24, 27, 63, 287; Copenhaver, "Magical Objects"; "Occultist Tradition," pp. 457-63; Copenhaver and Charles Schmitt, *A History of Western Philosophy*: Vol. 3, *Renaissance Philosophy* (Oxford: Oxford University Press, 1992), pp. 24-37, 196-209, 239-60.

seen in nature, the textual manifestation of magical objects came not merely to represent the evidence but actually to constitute the evidence, displayed in words and, more and more, in images. The continuities of the magical universe were marked and its powers were activated by visual signs – by Agrippa's picture of a dragon (fig. 1), for example. Since antiquity, such images had been part and parcel of magic; pictures like those in Agrippa's book worked together with words for mutual confirmation. Through the sixteenth century, the new technology of printing strengthened this partnership by multiplying, stabilizing, and disseminating images on the printed page. New techniques of picturing (perspective, shading, woodcuts, engraving) dazzled the eye with magical sights seldom seen before, picturing them naturalistically and broadcasting them in books, broadsheets and prints. As magical objects proliferated in word and image, the new learning and the new art made them more believable.[20]

Consider the monster purportedly born in Ravenna in 1496: an armless hermaphrodite with wings, a horn on its head, an eye on its knee and one eagle's talon in place of a foot. Broadsheets depicting this prodigy (and many others) had been circulating for years in Italy and Germany when one came to the attention of a Florentine apothecary, Luca Landucci, in 1512. The image itself compelled belief. "I saw it painted [*dipinto*]," Landucci exclaimed, "and anyone who wanted could see the painting in Florence" – pictorial proof of nature's horrors and God's impending wrath.[21] Agrippa's world was full of such wonders.[22]

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[20]Agrippa, *Opera*, I, 272; Hans Dieter Betz, ed., *The Greek Magical Papyri in Translation, Including the Demotic Spells* (Chicago: University of Chicago Press, 1986), pp. 17-23, 102, 125, 134, 143-50, 167-71, 268-99, 318-21; Elisabeth Eisenstein, *The Printing Press as an Agent of Change: Communications and Cultural Transformations in Early-Modern Europe* (Cambridge: Cambridge University Press, 1979), pp. 67-70, 254-72, 467-70, 485-8, 555-6; ; Copenhaver, "A Show of Hands," in *Writing on Hands: Memory and Knowledge in Early Modern Europe*, ed. Claire Richter Sherman (Washington, D.C.: Folger Shakespeare Library, 2000), pp. 46-59.

[21]Daston and Park, *Wonders*, pp. 177-90; Ottavia Niccoli, *Prophecy and People in Renaissance Italy*, trans. Lydia Cochrane (Princeton: Princeton University Press, 1990), pp. 30-60; Luca Landucci, *Diario fiorentino dal 1450 al 1516, continuato da un anonimo fino al 1542, pubblicato sui codici della comunale di Siena e della Marucelliana,* ed. Iodoco del Badia (Florence: Studio Biblos, 1969), p. 314.

[22]Daston and Park, *Wonders*, pp. 67-75, 145, 199; Grafton, "Humanism and Science in Rudolphine Prague," in *Defenders of the Text*, pp. 178-203; Copenhaver, "Two Fishes"; Keith Thomas, *Religion and the Decline of Magic* (New York: Charles Scribner's Sons, 1971), pp. 212-52; Jean Céard, *La Nature et les prodiges: L'Insolite au XVI^e^ siècle* (2nd ed.; Geneva: Droz, 1996); Kieckheffer, *Magic*, pp. 16-17, 56-94; William B. Ashworth, "Natural History and the Emblematic World-view," in Lindberg and Westman, *Reappraisal*s, pp. 303-32; Richard Gordon, "Aelian's Peony: The Location of Magic in Graeco-Roman Tradition," *Comparative Criticism* 9 (1987), 59-95; William Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton: Princeton University Press, 1994); David Freedberg, *The Eye of the Lynx: Galileo, His Friends, and the Beginnings of Modern Natural History* (Chicago: University of Chicago Press, 2002), pp. 1-3, 186-94.

More elegant evidence from the notebooks, drawings and paintings of Leonardo da Vinci (1452-1519) also shows how picturing made magical objects more credible. Leonardo compiled a bestiary, a file of the allegories and emblems that were the court painter's stock in trade, which included over a hundred species, some of them magical. One of its sources was the work of a fourteenth-century astrologer, the *Acerba* of Cecco d'Ascoli, who describes the dragon, greatest of all serpents and famed among magicians, armed with a poisonous tail and monstrously cruel.[23] Leonardo not only described and drew the magical dragon; he also built one.

According to Giorgio Vasari (1511-1571), the Florentine painter and academician who wrote the first great history of art, Leonardo actually assembled a little living dragon: "On a very peculiar green lizard ... he put wings made out of scales taken from other lizards ... so that they quivered from the movement when it walked; he made eyes, a horn and a beard for it, tamed it and kept it in a box, and it made all his friends run away afraid when he showed it to them." Leonardo's procedure recalls instructions that he left for inventing images of animals. "You cannot make any animal unless each of its own limbs by itself resembles a limb from one of the other animals," he wrote. "Thus, if you wish to make an animal that you have devised seem natural – a dragon, let's say – take the head from a mastiff or hound, the eyes from a cat, the ears from a porcupine, the nose from a greyhound, the brow from a lion, the temples from an old rooster, the neck from a water-turtle."[24]

Dragons of this sort appear in Leonardo's drawings, some of them made as studies for paintings. The background of the unfinished *Adoration of the Magi* (c. 1481), for example, shows two men in combat, riding horses long admired as effective statements of equine anatomy. But a preparatory sketch reveals that Leonardo had conceived these two believable animals as fighting a dragon. Other drawings (fig. 2) show forms of dragons flowing from images of horses and cats or linked to heraldic griffins and schemas from pattern-books. In such images, the magical dragon draws its credibility not only from juxtaposition with familiar animals like horses but also from Leonardo's meticulous

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[23]Jean Paul Richter, *The Literary Works of Leonardo da Vinci* (2nd ed; Oxford: Oxford University Press, 1939), I, 382 (670); II, 262 (1224), 264-5 (1231-2), 266-8 (1234, 1239-40), 270-1 (1248-9); Cecco d'Ascoli, *L'Acerba, secondo la lezione del Codice eugubino dell'anno 1376*, ed. Basilio Censori and Emidio Vittori (Verona: Valdonega, 1971), p. 125; Martin Kemp, *Leonardo da Vinci: The Marvellous Works of Nature and Man* (Cambridge: Harvard University Press, 1981), pp. 152-7, 164-7, 281; Kemp and Jane Roberts, *Leonardo da Vinci* (New Haven: Yale University Press, 1989), pp. 155-7; Wilma George and Brunsdon Yap, *The Naming of the Beasts: Natural History in the Medieval Bestiary* (London: Duckworth, 1991), pp. 66-8, 89-90, 192-3, 199-203; Lynn Thorndike, *A History of Magic and Experimental Science* (New York: Columbia University Press, 1923-58), II, 948-68; Daston and Park, *Wonders*, pp. 39-43, 52, 76; Pamela Gravestock, "Did Imaginary Animals Exist," in *The Mark of the Beast: The Medieval Bestiary in Art, Life, and Literature*, ed. Debra Hassig (New York: Garland, 1999), pp. 119-39.

[24]Giorgio Vasari, *Le Vite de' piu eccellenti pittori, scultori e architettori nelle redazioni del 1550 e 1568*, ed. Rosanna Bettarini and Paola Barocchi (Florence: Studio per Edizioni Scelte, 1966-97), IV, 21, 34-5; Richter, *Literary Works*, I, 342 (585).

control of anatomy, as in the description above of his compositional process.[25] Art in Leonardo's manner helped people used to reading dragons in the world – as if it were a text – to picture them as well, and the plausibility of such pictures, which were windows into the world of magic, was indistinguishable from the credibility of other natural objects skillfully drawn or painted.[26]

MAGIC ON TRIAL

Powerful evidence of how seriously magic was taken in Leonardo's day was the vehemence of religious opposition to it. Texts that incriminated certain objects as magical had long been feared as dangers to faith and morals, which is why a book that Leonardo used, Cecco d'Ascoli's *Acerba*, was burned along with its author in 1327. Far away, but not long after this double execution, another court sat in Constantinople's church of Hagia Sophia around 1370 to hear testimony about such books from one Phoudoulos. Accused of having "unclean" books, Phoudoulos confessed and named a physician, Syropoulos, as his source. Syropoulos led the court to another physician, Gabrielopoulos, whose residence was searched and whole boxes of books discovered. One suspicious work was called *Kyranides*; another was a book of spells by Demetrios Chloros, like Gabrielopoulos a cleric and physician. When Chloros claimed that his magic books were no different than medical texts, other physicians cried outrage: Chloros disgraced the art of medicine, they complained, insulting their heroes, the ancient physicians Hippocrates and Galen, by calling them magicians.[27]

What was so alarming about these books? The *Kyranides* might be just a crude natural

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[25]Vasari, *Vite*, IV, 22-5, 31; Pietro C. Marani, *Leonardo da Vinci: The Complete Paintings*, trans. A.L. Jenkens (New York: Abrams, 2003), pp. 101-17; Kemp and Roberts, *Leonardo*, pp. 23-65, 54, 66, 96, 145; Arthur Ewart Popham, *The Drawings of Leonardo da Vinci* (New York: Reynal and Hitchcock, 1945), pp. 32-8, 109, 112-13, 116-22, 125, plates 62, 80, 86-8, 104-14, 125; Popham, "The Dragon-Fight," in *Leonardo: Saggi e ricerche*, ed. Achille Marazza (Rome: Libreria dello Stato, 1954), pp. 223-7; Kemp, *Leonardo*, pp. 54-8.

[26]Michel Foucault, *Les Mots et les choses: Une Archéologie des sciences humaines* (Paris: Gallimard, 1966), pp. 13-14, 34-59, 128-32; Copenhaver, "Did Science Have a Renaissance?" pp. 403-7. The notion of *picturing* used here is adapted from its application by Svetlana Alpers to Dutch art in *The Art of Describing: Dutch Art in the Seventeenth Century* (Chicago: University of Chicago Press, 1983); Freedberg, *Lynx*, pp. 5-6, 284-6, stresses both the limitations of picturing and its importance for the Lincean Academy; see also Freedberg, *The Power of Images: Studies in the History and Theory of Response* (Chicago: University of Chicago Press, 1989), especially chapters 9 and 10; Caroline Jones and Peter Galison, ed., *Picturing Science, Producing Art* (London: Routledge, 1998), especially the essays by Daston, Freedberg, Koerner, Park, Pomian, and Snyder.

[27]Antonio Rigo, "Da Costantinopoli alla biblioteca di Venezia: I Libri ermetici di medici, astrologi e maghi dell'ultima Bisanzio," in *Magia, alchimia, scienza dal '400 al '700: L'Influsso di Ermete Trismegisto*, ed. Carlos Gilly and Cis van Heertum (Venice: Centro Di, 2002), I, 69-70; above, n. 22.

history, harmlessly listing plants, stones and animals under letters of the Greek alphabet, but it was ascribed to Hermes Trismegistus and advertised magical plants and animals which, like Agrippa's dragon, threatened to attract the attention of demons. When the *Kyranides* told its readers how to put things together to make medicine (a hoopoe's heart, hair from a seal, green jasper and peony root, for example, are items in one remedy of great value), it showed them magical objects with alarming powers.[28]

Another Hermetic book describes the simple peony as "a sacred plant, revealed by God to Hermes Trismegistus as a remedy for mortals, ... as noted in the holy books of Egypt," recommending it for fever and epilepsy and as a fumigant against demonic possession: "whoever has some part of its root, if the unutterable names of God are inscribed on it [with magic signs], need have no fear of demons." Galen, who was not interested in smoking out demons, had seen a boy cured of epilepsy by the peony amulet, which shows how faint the line between medicine and magic could be. In any case, making magical cures out of natural objects became an offense against the Christian religion.[29]

Yet the attractions of magic were powerful, strong enough to tempt many early modern writers to risk religious persecution. Even after the Catholic Inquisition made oppression more efficient, the literature of magic kept growing – in Venice, for example. The Inquisition arrived there in 1547 but paid little attention to magic until papal opposition intensified in the 1580s. The Index of Forbidden Books was in place by 1559, but its main effect was regional, on printing and selling books in Italy. Books were still smuggled, and manuscripts were still copied. Commerce in magical texts flourished: clergy were active in the trade and found customers everywhere in Venetian society, moved by love or hate or mere curiosity.[30]

During the sixteenth century and long afterward, books about magic, some illustrated like Agrippa's, poured from the presses. Yet something changed as Agrippa's book grew old and famous – ridiculed by the French satirist François Rabelais (1494-1553), put on stage by the English playwright Christopher Marlowe (1564-93), attacked by the leading critics of magic, and constantly copied by its foremost advocates. By the time an English translation of the *De occulta philosophia* appeared in 1651, the pioneers of a new science had turned against traditional wisdom and the magical principles that Agrippa derived

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[28]*Kyranides* 21 (Kamaikis ed., 55.96-102); Festugière, *Révélation* , I, 214-15.

[29]*Catalogus codicum astrologorum graecorum*, ed C.A. Ruelle (Brussels: Lamertin, 1911), VIII.2, 169-70; Galen, *De simplicium medicamentorum temperamentis* (Kühn, XI 792, 858-61); Festugière, *Révélation*, I, 77, 157; G.E.R. Lloyd, *Greek Science After Aristotle* (London: Chatto and Windus, 1973), pp. 136-53; *Magic, Reason and Experience: Studies in the Origin and Development of Greek Science* (Cambridge: Cambridge University Press, 1979), pp. 42-9; above, n. 13.

[30]Federico Barbierato, "La Letteratura magica in fronte all'Inquizione veneziana fra '500 e '700," in *Magia, alchimia, scienza*, I, 135-75.

from it.[31]

There were many reasons for their disenchantment, but low on the list was ecclesiastical censure. Galileo Galilei (1564-1642) was more at risk for contradicting Aristotle than for casting horoscopes, in an age when popes still wanted to know what the stars had in store for them. In part, the erosion of belief in magic reflected a general decline of the physics of qualities and its metaphysical foundations which, whether Aristotelian or Platonic, gave magic its theoretical grounding in Agrippa's books and other sixteenth century works.[32] In part, however, it was also new criteria of intelligibility expressed in new forms of visualization that caused magical objects and images to lose their credibility and eventually to fall out of sight.

VIRTUES DORMITIVE AND VISUAL

Before Galileo, Francis Bacon (1561-1626) and René Descartes (1596-1650) undermined the foundations of Agrippa's magical cosmos, however, others were shoring them up. One such effort, remarkable for its rich learning, acute philosophizing and explanatory ambition, appeared in 1548: *De abditis rerum causis* (*On Hidden Causes*).[33] This very influential book by Jean Fernel (c. 1497-1558), a French physician, was still finding buyers when Bacon, Galileo and Descartes were all dead and famous; it had seen nearly thirty editions in the century since its first publication. Born in the late fifteenth century and educated when Paris was the citadel of late scholasticism, Fernel was a great innovator in the theory and practice of medicine. Physician to King Francis I, who died of venereal disease despite his best efforts, he interpreted ancient medical texts by using the new philology. The old authorities persuaded him that occult qualities were powerful tools for explaining and treating human illness.

Fernel's book therefore exalts occult forces in medicine, making an expert case for a rationalized occult therapy on principles taken from the best classical sources – Hippocrates, Plato, Aristotle, Galen and many others. To construct a method for occult medicine, he repudiated medical empiricism and advocated rationalism. He was no patient student of pathological particulars, accumulating observations to wear down the theory of magical medicine. On the contrary, he embraced that theory and sought to

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[31]*Three Books of Occult Philosophy Written by Henry Cornelius Agrippa of Nettesheim, Counsellor to Charles the Fifth, Emperor of Germany, and Judge of the Prerogative Court, Translated out of the Latin into the English Tongue by J.F.* (London: Gregory Moule, 1651); in Thorndike's *History*, two volumes cover the seventeenth century, leaving only six for the previous sixteen; for the decline of magic's reputation, see Copenhaver, "Occultist Tradition"; see also Rabelais, *Le Tiers livre*, 25; Marlowe, *Doctor Faustus*, I.i.111.

[32]Walker, *Magic*, pp. 205-12; Copenhaver, "Occultist Tradition"; Stillman Drake, *Galileo at Work: His Scientific Biography* (Chicago: University of Chicago Press, 1978), pp. 35-6, 55, 169-190, 236, 278-88, 313.

[33]*Ioannis Fernelii Ambiani de abditis rerum causis libri duo* (Venice: Andrea Arrivabene, 1550).

extend and refine it, not destroy it. In the process, he not only defended occult qualities but also claimed that they were no less intelligible than their manifest counterparts. [34] Although Hippocrates was his first inspiration, Fernel knew that medical confidence in elements and qualities had become firm only with Galen, who developed his medical system in a post-Aristotelian framework. The universe in which a wet, cool, watery drug cures a dry, hot, fiery disease is the world in which the four elements constitute and account for everything beneath the moon. Fernel realized that Galen's extension of the Aristotelian and Hippocratic project was incomplete, however, and that Galen himself had to look – timidly – beyond the elements in order to explain common but perplexing medical phenomena. (One such puzzle was the "French disease" that killed Fernel's royal patient, Francis I, an ailment of the new age and unknown to Galen.) In effect, Fernel wanted to improve on Galen, deriving a more effective therapy and a more rigorous nosology from the physics of qualities on which magical theory was based. His key conviction, briefly stated, was that occult forces – arising from form, not matter – should cure contrary occult diseases, just as the manifest powers of the four material elements cure contrary manifest diseases.[35]

For Fernel, the paradigm of a manifest and material cause was hot, dry, light fire. Our perception that fire has such features arises from sensation; what we really sense, however, are not features of the object but its effects on us. "Because you have sensed that fire burns, you judge it hot," he explains, "in the same way, because you have often observed that a magnet attracts iron, you should conclude from the result which you see that there must have been something antecedent."[36] Fernel maintained that access to qualities of any kind – material or formal, manifest or occult – is by inference rather than sensation. Beyond inferring that a burning sensation is caused by a feature of the object and then calling this feature "hot," one can say nothing more about the cause of the sensation.

What about opium? Do we sense its dormitive virtue? No: on Fernel's theory, we infer that opium has such a virtue because it makes us feel drowsy. We perceive neither opium's dormitive virtue nor the hot quality of fire. "If I ask for the cause of fire's burning," he explains,

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[34]For a summary of the recent literature on Fernel, see John M. Forrester and John Henry, ed. and trans., *The* Physiologia *of Jean Fernel (1567)* (Philadelphia: American Philosophical Society, 2003), pp. 1-12; for the older view of Fernel as a crusader against magic, cf. Charles Sherrington, *The Endeavour of Jean Fernel* (Cambridge: Cambridge University press, 1946).

[35]Hippocrates, *De morbo sacro*, 1-5, 18; [Galen], *De affectuum renibus insidentium dignotione* (Kühn, XIX.643-98); Fernel, *De abditis*, pp. 5-7, 101, 109, 120, 153-6, 204-6, 217-23, 235-6, 249, 280-2, 292-3, 304-5; Julius Röhr, *Der okkulte Kraftbegriff im Altertum* (*Philologus*, Supplementband 17.1) (Leipzig: Dieterich, 1923), pp. 96-133; Lloyd, *Magic*, pp. 15-29; *After Aristotle*, pp. 136-53.

[36]Fernel, *De abditis*, pp. 17-23, 64-5, 82, 149-50, 159, 173-9, 284, 294.

> you can say no more than that it comes from intense heat and that this is its nature and property. Having given this confident answer, you will seem to have replied fully and learnedly. Yet when I say that the magnet attracts iron or that peony stops epilepsy by an innate property, according to you I have not expressed the cause clearly enough. Why so? Why make what is common to both cases special to one, as if it were privileged? Perhaps this is the difference: the property of fire, because it is more familiar, is defined by the special names 'heat' and 'lightness,' while no name has yet been applied to the properties of the magnet, peony and things of that kind.... Primary qualities do not explain everything, and … we should be no more amazed by the characteristics of occult properties than by those of the elements.... [Such] properties arise not from the elements or from matter but from form alone.[37]

For Fernel, then, the difference between manifest and occult is merely nominal. Qualities traditionally called occult differ from the manifest only because we encounter the latter more often and give them common names like "heat" instead of ungainly labels like "dormitive virtue." The distinction, which makes no real difference, arises only from habit, taxonomy and method, not from physics, ontology or epistemology. In reality, all qualities are imperceptible, whether they are called occult or manifest.

But Fernel did not stop with denying the usual distinction between manifest and occult qualities. He also attempted to replace epistemological puzzles with clinical data by invoking occult *faculties* rather than occult *qualities*. Plain facts of clinical experience were that opium makes people sleepy and hemlock kills them. By isolating faculties as efficient causes of clinical facts that involve both drugs and patients, Fernel could make sense of opium's effect while evading the epistemological gap between the drug's (objective) dormitive quality and the patient's (subjective) dormitized experience. The drug's faculty is just the efficient cause of narcotic effects observed in the patient. About faculties Fernel could say no more, except that they were products of divine form.[38]

As long as the debate stayed fixed on qualities, the epistemological impasse scouted by Fernel blocked further movement within the Aristotelian-Galenic framework. In the next century, Galileo, Descartes and others would eliminate the obstacle by discarding that framework along with one of its root metaphors: qualities (hot, cold, wet and dry) that were haptic rather than visual, felt rather than seen. Trying to cover the whole world – from remote stars to miniscule corpuscles – with the same physics and geometry, Descartes pictorialized its tiniest parts, just as Galileo had published pictures of moons circling Jupiter that were hidden to the naked eye. To show that all nature's works are effects of the same material causes – the shape, size, position and motion of its smallest parts – Descartes depicted invisible micro-objects as they might appear in the macro-world: special grooved particles (fig. 3), for example, solve the puzzle of magnetism by screwing their way mechanically through the earth.[39] Many such explanatory pictures

[37]Fernel, *De abditis*, pp. 285-7.

[38]Fernel, *De abditis*, pp. 151-6, 173-9; Lloyd, *After Aristotle*, pp. 141-3.

[39]Descartes *Oeuvres*, ed. Charles Adam and Paul Tannery (Paris: Vrin, 1996), VIII, 283-315.

clarify mechanical arguments made by Descartes that would otherwise be harder to grasp, and the language of vision (ideas are clear and distinct; a natural light illuminates understanding) also pervades Cartesian philosophy. Images made it more plausible to talk about invisible mechanisms working beneath visible phenomena – including effects commonly treated as magical, such as magnetism, sympathies and antipathies.[40] While knowing was like seeing for Descartes, Fernel had been committed to a knowing-as-touching metaphor. His physical primitives were not shape, size, position and motion but fire, air, water and earth – felt but not seen as hot, cold, wet and dry.[41]

When new theories, with pictures clarifying words and numbers, displaced the old physics, likewise displaced were the old occult qualities, rooted in intuitions that were more haptic than visual. The same use of pictures that served magic so well in the sixteenth century was thus turned against it by mechanical philosophers of the seventeenth century, who made images of what they could not see but had to assert: the microscopic particles and mechanisms that caused macroscopic phenomena. Although magical objects and their sensible effects could be observed, the occult (literally, hidden) causes of those effects had always eluded observation. To account for such things, insofar as experience made them veridical, proponents of the mechanical philosophy visualized invisible mechanisms and published pictures of them. Hence, pictures worked both for and against magic in early modern Europe, at first promoting the reality of magical objects but eventually eroding their theoretical foundations.

New modes of visualization, assisted by new arts of picturing, eventually helped to make magic a mere spectacle, an illusion, ready for the hilarious disclosure of its emptiness by the French dramatist Molière (1622-73). Molière gave the history of science its best joke in *Le malade imaginaire* (1673), the comedy that exploded the pretense of occult qualities. In the end, laughter was a powerful force in driving magic offstage – laughter that marked a fundamental shift in standards of intelligibility.[42]

One of the themes of *The Imaginary Invalid* is false learning, a pose that Molière found especially funny in physicians, who made their patients pay for empty talk. Diafoirus, the learned healer of the play, describes the ideal physician as one who "won't budge

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[40]J.F. Scott, *The Scientific Work of René Descartes* (London: Taylor and Francis, 1952), pp. 71-81; William R. Shea, *The Magic of Numbers and Motion: The Scientific Career of René Descartes* (Canton: Science History Publications, 1991), pp. 129-47, 205-18, 228-49; Copenhaver, "Occultist Tradition," pp. 469-73.

[41]Aristotle, *De anima*, $435^{a}11$-$^{b}25$; cf. *De sensu*, $436^{b}13$-$37^{a}31$; *Metaphysics*, $980^{a}23$-7; Fernel, *De abditis*, pp. 10-13; David Lindberg and Nicholas Steneck, "The Science of Vision and the Origins of Modern Science," in *Science, Medicine and Society in the Renaissance: Essays to Honor Walter Pagel*, ed. Allen Debus (New York: Science History Publications, 1972), II, 29-45.

[42]Molière, "Le Malade imaginaire," in *Oeuvres complètes* (Paris: Éditions du Seuil, 1962), p. 628 (1.1).

from an opinion, … binds himself *blindly* to the opinions of the ancients and has never wished to understand … the pretended discoveries of our century on the circulation of the blood and other notions of that ilk."[43] Argan, the hypochondriac of the play's title, reveals his faith in the old occult qualities, as opposed to the newer mechanical notions, while he catalogues his medicines: "a little enema, insinuative, preparative and emollient, ... a hepatic julep, soporific and somniferous, … a nice purgative ... to flush out and evacuate the bile."[44] The play's finale in macaronic Latin is a song and dance burlesque of the granting of a medical diploma. The *primus doctor* asks: why does opium bring on sleep? The candidate replies that opium's effect comes from its narcotic power:

> And to your quiz
> My answer is
> A virtue dormitive,
> Whose nature is
> To soften up the senses.

"Good answer – oh good, good, good!" is the verdict: the candidate has responded learnedly; his ordeal is over; his new colleagues exult.[45]

The traditional philosophy and medicine ridiculed by Molière had treated qualities of objects – their powers, colors and other features – as entities apart from matter, but the mechanical philosophers saw them as nothing but material structures. In fact, since they could not really see these structures, they posited invisible microstructures, picturing them in visual metaphors based on artificial macroscopic objects – balls, canes, keys, screws, locks, clocks – that blurred the line between nature and art and demystified the origin of qualities. For objects that could not be sensed, they postulated features by analogy between the seen and the unseen. If something could not be visualized in this way, it could be dismissed as occult, which, for those who abandoned the old physics of quality, had come to mean "unintelligible" rather than "hidden."[46]

The corpuscles theorized by Robert Boyle (1627-91), though endowed with picturable properties of size, shape, and motion and redefined as *primary* qualities, were just as hidden as occult qualities and no more observable. Boyle argued that observable

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[43]Molière, "Malade ,"pp. 642-3 (2.5).

[44]Molière, "Malade ,"p. 628 (1.1).

[45]Molière, "Malade," pp. 659-61.

[46]Keith Hutchison, "What Happened to Occult Qualities in the Scientific Revolution," *Isis*, 73 (1982), 233-53; "Dormitive Virtues, Scholastic Qualities, and the New Philosophies," *History of Science*, 29 (1991), 245-78; cf. Copenhaver, "Occultist Tradition," pp. 457-60, 503, with nn. 18 and 111, which maintains that occult qualities were *not* unintelligible in the traditional Peripatetic framework; on art and nature, see Daston and Park, *Wonders*, pp. 260-5, 280-93, 298-9, 314.

properties emerged only when these least bodies aggregated in structures; however, the resulting *secondary* qualities, such as color or odor, were not the scholastic entities that Molière mocked and Boyle found incomprehensible. Never entirely escaping the world of magic, Boyle improved on occult qualities by replacing them with other indiscernibles, tiny bodies to which he imputed properties like those of ordinary objects – ground glass, for example. Physicians traditionally treated this substance as a poison and therefore labeled it occult, as possessing a "deleterious faculty, … a peculiar and superadded entity." But for Boyle there was "nothing distinct from the glass itself, ... [whose] sharp points and cutting edges are enabled by these mechanical affections to pierce or wound ... the stomach and guts."[47]

For Boyle, in other words, the toxic virtue in glass is just its structure, not a separate faculty or quality. To explain the effects of a poison by qualities only posited ingredients and tagged them with the very features whose explanation was sought, like the dormitive virtue of opium; naming notional entities in this way explained nothing. "What is it to me to know that such a quality resides in such a principle or element whilst I remain altogether ignorant of the cause?" Having framed this question in the *Sceptical Chymist*, Boyle went on to ask "how little does the chymist teach the philosopher of ... purgation if he only tells him that the purgative vertue of medicines resides in their salt? … 'Tis one thing to know a man's lodging, and another to be acquainted with him." Looking for substance and quality while overlooking structure was like trying to explain a clock by telling whether its works are brass or steel while ignoring their configuration.[48]

According to the mechanical philosophers, the structures underlying phenomena previously understood as occult are not imperceptible in their nature, unlike the corpuscles that they thought to make up structures and also unlike the old occult qualities that eluded observation because they arose from immaterial forms. Minute structures are not perceived simply because the human senses are weak. Because we cannot see or feel "the Bulk, Texture, and Figure of the minute parts of Bodies, ... we are fain to make use of their secondary Qualities, ... which ... are nothing but bare Powers. For the Color and Taste of Opium, are, as well as its soporific and anodyne Virtues, mere Powers depending on its primary Qualities." This was the view of Boyle's contemporary, John Locke (1632-1704), who helped Boyle shut the door on the old physics of qualities while using pictorial keys and locks to open the way to a sharper, visual understanding of matter.[49]

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[47]*The Works of the Honourable Robert Boyle*, ed. Thomas Birch (London: W. Johnston et al., 1772), III, 4, 11, 13, 18-25, 46-7; Peter Alexander, *Ideas, Qualities, and Corpuscles: Locke and Boyle on the External World* (Cambridge: Cambridge University Press, 1985), pp. 5-9, 18, 39, 61-3, 85; Copenhaver, "Occultist Tradition," pp. 488-90.

[48]Boyle, *The Sceptical Chymist* (London: Dent, 1911), pp. 178-83; Alexander, *Ideas*, pp. 37-40, 50-2.

[49]John Locke, *An Essay Concerning Human Understanding*, ed. Peter Nidditch (Oxford: Clarendon Press, 1975), pp. 134-5 (2.8.8-10), 140-1 (2.8.23), 300-1 (2.23.8-9), 555-6 (4.3.25); Alexander, *Ideas,* pp. 48, 55-9, 61-88, 115-25, 131-4, 139, 150-1, 162-74; Copenhaver,

By reducing causality to structure, Locke and Boyle brought occult phenomena within the scope of the new science. Boyle even proposed a theory to cover action-at-a-distance and its unobservable agents. Rather than attributing an electrical property to amber in order to explain its power of attracting chaff when rubbed, he argued that this familiar but puzzling effect resulted from an effluvium, a structure of imperceptible particles with no properties but size, shape and motion. Agrippa had referred amber's attractiveness to an occult virtue that was not only unobserved as anything distinct from its visible effects but also unlike anything otherwise observed. Although their smallest parts were ultimately no more perceptible than Agrippa's occult qualities, Boyle's effluvia had two advantages: an imputed structure made them seem concrete and intelligible; and an analogy with visible vapors brought them within range of everyday experience.[50]

MAGIC OUT OF SIGHT

With his theory of occult faculties, Fernel anticipated the use that mechanical philosophers made of the term "power" to distinguish features of an object from its ability to affect an observer – or a patient.[51] But several things made the mechanical philosophy and its microscopic particles more credible than Fernel's occult faculties and thereby weakened the theory of magic: one strength of the new science was its claim that unseen structures are intelligible by pictorial analogy with gross phenomena, natural or artificial; another was its confidence that new instruments could reveal features of the world never seen before because they were too small or too far away.

When Galileo, Descartes, and their successors looked for distant moons or hidden microstructures, new tools – telescopes and microscopes – equipped them better than Fernel. Agrippa had found mirrors and lenses merely spellbinding, but in his *Magia naturalis* of 1589 Porta speculated about optical instruments, whose scientific use awaited the next century. Meanwhile, the influence of ancient atomist texts, whose recovery started in 1417 and opened several lines of attack on Aristotle, grew with no help from optical instruments, though it took a long time for atomism to penetrate natural philosophy. Near the end this slow process came Galileo's account of particulate matter in *Il Saggiatore* (*The Assayer*) of 1623, which also mentions a magnifying device. Galileo then built the instrument used to produce the first scientific illustration made with a microscope, a 1625 broadsheet showing three magnified bees. Another atomist, Pierre Gassendi (1592-1655), looked through a microscope at crystals and saw their geometry,

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"Scholastic Philosophy," pp. 524-8, 538-46; "Astrology and Magic," pp. 274-87; "Occultist Tradition," pp. 454-60, 490-3.

[50]Boyle, *Works*, pp. 660, 678-89; *Sceptical Chymist*, pp. 104-5; Agrippa, *Opera*, I, 25, 38, 45, 274, 465-6; Alexander, *Ideas*, p. 64; Catherine Wilson, *The Invisible World: Early Modern Philosophy and the Invention of the Microscope* (Princeton: Princeton University Press, 1995), pp. 229-32, which stresses the weakness of the argument from analogy, it disregard of differences between macro- and micro-objects – as some of the mechanical philosophers realized.

[51]Locke, *Essay*, 2.8.2, 7-10, 15, 17, 22-3, 26; Alexander, *Ideas*, pp. 115-22, 131-4, 150-67.

while Descartes theorized about magnifying lenses and imagined pictures of an invisible micro-world.[52]

"By means of the Telescopes," wrote Robert Hooke (1635-1703) in 1665, "there is nothing so far distant but may be represented to our view, and by the help of Microscopes, there is nothing so small as to escape our inquiry. Hence there is a new visible world discovered, … all the secret workings of Nature." Encouraged by their new instruments, and falsely assuming that pictures of the world could go all the way down, the mechanical philosophers thought it possible to shift from haptic to visual primitives, at least in theory. Just as the telescopic sight of moons circling Jupiter extended terrestrial physics to the whole cosmos, microscopic views of minute structures elicited analogies from macro-objects to micro-objects. Depicting real things never seen before**,** Hooke used the engravings of his lavishly illustrated *Micrographia* to picture cheese mold that looked to him like "microscopical Mushroms" and a gnat's antennae that seemed like "the horns of an Oxe."[53]

By the time Hooke published his microscopic investigations, the mechanical philosophy had established itself as the new standard of intelligibility in natural-philosophical explanation. But fascination with the microscope was more the effect than the cause of new ways of explaining natural phenomena by picturing them. If the new apparatus of microscopy came too late to explain the transition from Fernel's occult physics of haptic qualities to a mechanical physics of pictured particles, where should we look? I suggest that Europeans in the interim were stimulated by medical debates about occult properties, provoked by atomist materialism, and seduced by the pictorial arts to prepare the way for that momentous change. This conjunction did not rid natural philosophy of wonders – far from it, as witness the revelations of strange new worlds under the microscope. Nor were hidden causes banished, though respectable researchers no longer called them occult. On the contrary, the physics of force and the embryology of *emboîtement* gave unseen objects a greater role than ever.[54] But debates about magic and occult qualities had also

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[52]Agrippa, *Opera*, I, 12-13, 32-3, 153-4; cf. II, 60-1; Galileo, *Opere*, ed. Ferdinando Flora (Milan: Ricciardi, 1953), pp. 171-2, 311-16; Descartes, *Oeuvres*, VI, 93, 196-211; Locke, *Essay*, pp. 175 (2.13.19), 295 (2.23.2); Daston and Park, *Wonders*, pp. 300, 323; Freedberg, *Lynx*, pp. 7, 33, 41, 71, 101-8, 114, 142, 151-4, 160-3, 219, 222-32, 276; Wilson, *Invisible World*, pp. 57-79, 85-8, 216, 238-43; Norma E. Emerton, *The Scientific Reinterpretation of Form* (Ithaca: Cornell University Press, 1984), pp. 42-3, 129-35, 148-53, 248**;** Copenhaver and Schmitt, *Renaissance Philosophy*, pp. 198-201; Copenhaver, "Occultist Tradition," pp. 475-80; Howard Jones, *The Epicurean Tradition* (London: Routledge, 1992), pp. 142-65.

[53]Robert Hooke, *Micrographia, or Some Physiological Descriptions of Minute Bodies Made by Magnifying Glasses with Observations and Inquiries Thereupon* (London: Martyn and Allestry, 1665), sig, aii, pp. 125-6, 185-6. Note the different, though not entirely contrary point made by Wilson, *Invisible World*, pp. 57-63, that "the microscope takes away the privilege of surface. What the object looks like on the outside is no guide to what it is.... And in the interior of things there is no resemblance ... even if we must call in the language of every day – of ropes, fibers, globules, forests, looms and children's toys – to describe it."

[54]Wilson, *Invisible World*, pp. 113-37; Copenhaver, "Occultist Tradition," pp. 493-502.

turned up new criteria for explaining the world of nature, criteria that helped natural philosophy picture a way out of magic.